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THE FUNCTION OF SCIENTIFIC STUDY IN A TRUE EDUCATION.

WHEN I was a young man fresh from college, heavily laden with the wisdom of a liberal education, it was an easy matter to discuss the fundamental problems of education. I usually began, as was quite the fashion of scholarly men in those days, with a display of my Latin. The word "education," I affirmed—and I had often heard erudite educators make the same assertion—is derived from the Latin words *e* and *duco*. *E* signifies "out of," and *duco* means "I lead." Therefore to "educate" is "to lead out." Hence education does not consist in storing the mind with information, but in drawing out its powers. Discipline is the essential thing; the getting of knowledge is secondary. So we said. And we proceeded to make distinctions between subjects, and to set up and to put down. There were "disciplinary studies" and "information studies," and we lauded the disciplinary studies and we deprecated the information studies. We pointed out the truly good studies, and the quite indifferent studies, and we maintained that the truly good studies gave a liberal education and made broad, balanced, all-around men, so disciplined that they were fitted for almost any sphere in life. Into whatever vocation they might be called, men so educated would only need to pick up the special information of the business, and then their all-around discipline and wide culture would render them strong and able and fitted for success; indeed, even stronger and abler and better fitted than if they had given their time to the special training of the vocation. And thus we set up an aristocracy of subjects and tabooed other subjects as plebeian. Out of the largeness of our minds and the liberality of our broad culture we exalted the favored few and contemned the rest. And in doing this we thought verily we were bringing learning to the aid of true education and were doing the great cause noble service.

But since those happy days of scholastic exaltation, I have had occasion to see something of the world as it is. I have even learned some things about Latin. I have found out that there is such a Latin word as *educare*, and that this word *educare* means "to nourish." It now appears that there are scholars who contend that the word "education" comes from this *educare*, and not from *e duco*. If this be so, "education" should mean the "nourishment of the mind." To nourish the mind is obviously to feed it with knowledge. For aught that now appears, then, we may flourish our Latin in support of the thesis that education is the acquirement of knowledge. The Latin will accommodate itself to the purpose of the advocate of either side, if selectively handled. Unfortunately, however, for the time-honored cause of discipline, one of our latest and ablest lexicons, edited by one of America's most noted philologists, takes pains to say that "there is no authority for the common statement that the primary sense of *educate* is to draw out or unfold the powers of the mind."

To the student of the real truth about education it is of no consequence whatsoever what the word means. It would not alter the nature or function of education one whit if it were called *chimo* or *chee foo*. So far as the real question is concerned, all this quotation of Latin is vanity, vanity, vanity.

When I was a member of the Euglossian Debating Society, which met at the district schoolhouse, we discussed on one occasion the profound question, "Which is most necessary to man, air or water?" This memorable debate comes forcibly to my mind when I hear educators discussing the relative values of "discipline" and "information" in education. A youth may become educated on "discipline" alone about as successfully as he may live on air alone. He may become educated on "information" alone about as successfully as he may live on water alone. If there be doubt on this matter let us put it to test in a tangible case. But let us not choose a phase of education so elusive and occult that we are likely to misunderstand each other when we talk about it. Rather let us select a function that is so tangible that there is no danger of mystification; for example, physical culture, just now in high vogue. What success could be anticipated if one set about educating his muscles by exercising them without nourishing them, or by nourishing them without exercising them? No better success, I think, would be attained with any other faculty or function similarly treated. It seems to me impossible properly to develop any mental faculty or function by exercising it without its approximate substance of thought, or by filling it with information without exercising it, if either thing were altogether possible. Each alike is futile without the other. Strenuous exercise of the mind without due substance of thought is as harmful as strenuous exercise of the muscles without due nourishment. The mightiest engine ever made is worthless without fuel. The richest of the coal beds can move no machinery unless burned in an engine. The traditional controversy between disciplinary studies and information studies is a controversy between partisans *both of whom are wrong*. The true education is conditioned on a proper combination of knowledge and of thinking, on a proper matching of information and of discipline. St. Paul said on a like subject: "Show me thy faith without thy works, and I will show thee my faith by my works." "Show me thy discipline without thy knowledge, and I will show thee my discipline by my knowledge," says the true scholar.

More than this, it is impossible to think properly on a subject without information relative to it. Ample knowledge is absolutely essential to the best thinking. Discipline without information is a delusion and a snare. The metaphysical disquisitions of mediæval times have given us abundant illustrations of this.

But this is not all. Neither discipline, in the old sense, nor information, in the similar sense, nor both together, represent the highest factor in education. It is not sufficient to learn what is already known. It is not sufficient to think the thoughts of others after them. To be fitted for a really intellectual life it is necessary to learn some things that are not known, to think some thoughts that have never been thought before; to grapple with new questions and to grapple anew with old questions; to investigate on one's own account. There come to every person fulfilling any worthy place in life new problems that must be solved by themselves and for themselves. I do not mean that it is the function of every person to make new discoveries in science or new creations in literature, but every individual life brings individual problems. These precise problems have never been presented to any other being. They cannot be solved by simply imitating something that can be learned, nor by repeating the thoughts of anyone who has gone before. They are new and original questions, and must be solved by original research. To be prepared for these questions the student should be trained in finding out new truth for himself; in other words, should be trained in independent research.

A complete education involves other factors, which time compels me to pass. I lay special stress on these because they especially concern the life which is immediately before the youth of today.

The subjects of education are divisible into two great classes: those which relate to the constitution of things, and those which relate to human devices and conventions; in other words, those which pertain to the divine creation and those which pertain to man's creation; or, in still other words, the natural sciences and the artificial sciences; the first includes the fundamental constitution of matter and the relations of matter to matter, the nature of energy and the relations of energies to energies, the formation of the earth and the host of heaven, the nature of life and its laws, the nature and functions of man himself; in short, those things which we recognize as the works of God. The latter involves those things which man has brought into existence as the result of his choice, his invention, his artifice, or his whim; the habits, customs, fashions, devices, and institutions of man, his languages, his political and social institutions, his industries, his ordinances, his varied creations.

What part shall the works of God and the ordinances of God have in the curriculum of a well-ordered school? These works and these ordinances are fundamental, for they condition our very existence. Not a breath do we draw, not a thought do we think, without the aid of chemical, physical, and biological activities. Our length of life and our success in action and in thought are conditioned by these indispensable functions within our persons and in our environment. The most extraordinary advances made in recent years in the preservation of life and the reduction of suffering have arisen from a study of these ordinances of our being and of our environment. If there were no other grounds for urging their study, the preservation of life and the promotion of our well-being would alone justify apportioning a large measure of time to these subjects, since they hold in themselves the issues of life and death. What untold misery, what unspeakable sorrow, what manifold death would have been saved had these subjects been assiduously investigated by all the universities for the last thousand years and the results assiduously taught by all the other schools!

Permanence is characteristic of these subjects. Chemical, physical, biological, and planetary laws were in action millions of years ago, and with little doubt they will continue in action for millions of years to come. Compared with them, the conventions of man are ephemeral and evanescent. We talk of ancient history, meaning the story of certain peoples two and three thousand, or at most five or six thousand, years ago. These are but things of yesterday compared with the great history of the earth and the stars, or the story of life. In this quality of permanence and endurance the fundamental sciences bear a quality which the transient institutions and conventions of man do not possess.

If we turn to the secular side, it may be remarked that these subjects have great industrial value. It is needless to say that the sciences have made extremely important contributions to most of our great industries. So vital is their industrial bearing that the chief educational agitation in Europe during the last few years has hinged upon the commercial value of elementary education in the sciences. The gigantic strides which Germany has made in commercial enterprise, under natural conditions not especially superior, have been quite surely due to the large attention given to these subjects in certain of her schools. The foremost nations are coming to recognize in scientific education a political factor of profound importance. If America is fully to establish and make permanent her leadership in the industrial world, it will be through training in the sciences, for by this in the future will leadership be conditioned.

As an element of individual equipment for the highest efficiency in many of the offices of life, a knowledge of the sciences is indispensable. In domestic economy, in sanitation, in many of the crafts, in agriculture, in pharmacy, in medicine, and even in law, in literature, and in the ministry, a large measure of familiarity with these subjects is of unquestionable value. No small familiarity is necessary to an intelligent reading of the publications of the day. Our magazines and our newspapers contain no trivial factor of sciences. It might be better, but, such as it is, it can be read with discriminating intelligence only through a knowledge of the fundamental sciences. This scientific factor is increasing year by year, and will certainly continue to grow during the next generation. To discriminate the good from the bad, at least elementary scientific schooling is requisite. We are daily becoming more and more dependent on scientific appliances. To deal intelligently with these, scientific instruction is needful.

As a training, the study of the sciences possesses its own peculiar value. It is not my function here to compare the disciplinary value of the natural sciences with that of the conventional sciences, but the high value of the former in intellectual training may be affirmed without hesitation. Their peculiar advantages as instruments of training lie in their tangible demonstrative character. Their field is rigorously controlled by law. Even though the combination of agencies be intricate and the results complex and obscure, law reigns and a rigorous mental procedure is demanded to secure the truth.

The sciences have peculiar value in training the mind to appreciate the co-operation of different agencies in a given phenomenon. It is not sufficient to know that a certain cause is operating in a certain phenomenon, and that a certain effect will be produced by it. It is necessary to know whether there are not other factors involved which will overwhelm it and produce an entirely different outcome. Questions of this class make up most of the issues of life. Very rarely does a single cause work alone to produce its own independent result. For the most part, the questions of life involve a combination of several influences, acting in different degrees, and the outcome is determined by the measure of participation of the respective factors. It is necessary to evaluate these and combine them to foresee the true result. Now this is eminently true of the problems of the natural sciences, and the training which they give in discriminating and evaluating the constituent factors is precisely that kind of discipline needed for the solution of the complex problems of life. This kind of discipline is not equally possible in some of the other subjects of study, because they are in their very nature selective and simple.

The disciplinary value of the sciences is greatly enhanced by experimentation. Scientific problems are solved, not simply by reasoning upon them, but by putting them to trial. There grows out of this an ability to test questions by experimentation, and withal a fixed disposition to do so. As a result, the mind so trained is less willing to rest upon simple reasoning, subject, as it is, to pitfalls here and there, but is predisposed to bring every question to the test of actual trial.

There has grown up with the sciences a distinctive mode of work, known as the scientific method. It is distinguished from previous methods in its constant appeal to observation and experiment, and to rigorous induction from these. Now, this scientific method is confessedly superior to all previous methods. It is coming to be the distinctive method of the age. It is being gradually introduced into other departments of thought and will at length beyond question come to be practically the one universal method of research. To the acquirement of this method the study of the natural sciences is the obvious avenue. To fail to acquire this method of intellectual procedure is to fail to acquire the highest and best method of modern times. If, therefore, the youths of today are to be prepared for the distinctive intellectual work of the next half-century, they should be trained in scientific work by the scientific method. The importance of this may not be fully appreciated today, but it will be realized twenty, thirty, forty years hence, when the youths of today are in the midst of mature life and taking part in its great battles.

The study of the sciences is helpful in bringing our youths into the spirit of the age, and aids them in being a living factor in it. The spirit of the age is a spirit of progress. The motto of the age is "On! On! On!" New truths, new philosophies, new inventions, new discoveries, new remedies, are the glory of our time, and the glory of science as well. But, while the spirit of science is one of unhesitating progress, it does not plunge recklessly into any scheme that may offer allurements to some promised good. It proceeds by testing every new proposition by all the resources of the scientific method. What is proposed is not accepted simply because it is proposed or because it promises some desired benefit. It is merely made a working hypothesis and put to experimental trial in an appropriate way. All that a new proposition can hope for under the scientific spirit is investigation. It is the scientific practice to make trial in a small experimental way before great interests are put in jeopardy. The ancient physicians tried their remedies on man by the wholesale. The scientific physician of today makes his tests on a few animals under close observation. When the scientific spirit shall control in the social and political world, we will make similar small experimental trials before we jeopardize the great interests of the nation by plunging heedlessly into revolutionary proceedings. Science is eminently progressive and has only anathema for opposition to progress, but its progress is based on cautious study, careful observation, and preliminary trial. It does not hold on to past measures until their accumulated weaknesses bring on a collapse and then recklessly swing over to some other practice, only to invite another collapse and reaction. Its mode is to move steadily and unhesitatingly, but yet carefully, on. When this mode comes to be dominant in civic and social life, it will be as great a boon to them as it already is to industrial life. It is therefore of the highest importance to the future of the American people that this conjoined spirit of progress and conservation shall come to be the dominant trait of our people.

Scientific studies carry with themselves distinctive moral attitudes which eminently commend them as factors in the curriculum of youth. Chief among these is their firm loyalty to truth. No matter what may have been previous beliefs and preferences, the true scientific student revises his views as evidence requires. Authority, tradition, current opinion all go for naught in the face of clear evidence. A readiness to abandon error and substitute truth is a prime quality in true scientific work. A devoted loyalty to the realities within us and about us, whether they accord with what we wish or not, is a fundamental trait of scientific morality.

I regret that time forbids me to dwell more at length upon the ethical aspects of scientific study. I must close with the remark that the enduring ordinances of creation are surely worthy of a large place in our studies beside the ephemeral devices of man; a study of the entities and energies that enter into the very constitution of the universe and of all its creatures deserves generous recognition, and the great histories of the whole may well form a groundwork for the little special histories in which we are more intimately and narrowly concerned.

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